Use of the great saphenous vein in place of left internal mammal artery in unconventional cases for left anterior descending artery revascularization

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Abstract

Introduction: For some patients whose LIMA cannot be used, surgeons have to choose other conduit materials to revascularize the LAD. This study was to explore the differences between SVG and LIMA used for LAD in terms of parameters measured by transit-time flow measurement (TTFM) and the early graft patency. Methods: A total of 374 patients who underwent CABG were included in this study. According to the strategy of the left descending artery (LAD) revascularization, 374 patients were assigned to two groups: a left internal mammal artery (LIMA)group(n=332) and a great saphenous vein (SVG) group (n=42). Results: Before propensity Score-Matched, compared with the LIMA-LAD group, the SVG-LAD group had a significantly higher MGF(37.85±23.28 vs 29.70±20.97ml/min, P=0.021),but a lower PI value (2.12±0.68 vs 2.65±1.01,P¡0.001).There was no significant difference between the two groups in terms of DF(P¿0.05). After 1:2 propensity Score-Matched, there were 114 patients were included (SVG-LAD 38, LIMA-LAD 76), there was no difference in the baseline data between the two groups. Compared with the LIMA-LAD group, the SVG-LAD group also had a lower PI value (2.07+-0.63 vs 2.74+-1.02,P¡0.001),and also a higher MGF(37.27+-24.31 vs 29.92+-21.92ml/min),but there was no statistically difference(P=0.109). There was no significant difference between the two groups in DF (P¿0.05). There was no difference among the two groups in patency rate(P=0.405). Conclusion: SVG-LAD has a higher MGF and a lower PI value than LIMA-LAD before PSM but just has a lower PI value than LIMA-LAD after PSM. There was no difference among the two groups in early patency rate.

Use of the great saphenous vein in place of left internal mammal artery in unconventional cases for left anterior descending arteryrevascularization: the perioperative outcomes

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Abstract

Introduction:

For some patients whose LIMA cannot be used, surgeons have to choose other conduit materials to revascularize the LAD. The objective of this study was to explore the differences between SVG and LIMA used for LAD in terms of parameters measured by transit-time flow measurement (TTFM) and the early graft patency detected by computed tomography angiography.

Methods:

From October 1, 2017 to October 31, 2019, a total of 374 patients who underwent CABG were included in this study. According to the strategy of the left descending artery (LAD) revascularization, 374 patients were assigned to two groups: a left internal mammal artery (LIMA)group(n=332) and a great saphenous vein (SVG) group (n=42). The baseline and perioperative blood parameters were compared for the three groups, as well as the early graft patency rates.

Results:

Before propensity Score-Matched, compared with the LIMA-LAD group, the SVG-LAD group had a significantly higher mean graft flow volume (37.85±23.28 vs 29.70±20.97ml/min, P=0.021),but a lower value of pulse index (2.12±0.68 vs 2.65±1.01,P¡0.001).There was no significant difference between the two groups in terms of DF(P¿0.05). After 1:2 propensity Score-Matched, there were 114 patients were included (SVG-LAD 38, LIMA-LAD 76), there was no difference in the baseline data between the two groups. Compared with the LIMA-LAD group, the SVG-LAD group also had a lower value of pulse index (2.07+-0.63 vs 2.74+-1.02,P¡0.001),and also a higher mean graft flow volume (37.27+-24.31 vs 29.92+-21.92ml/min),but there was no statistically difference(P=0.109). There was no significant difference between the two groups in DF (P¿0.05). There was no difference among the two groups in patency rate(P=0.405).

Conclusion:

SVG-LAD has a higher intraoperative MGF and a lower value of the PI than LIMA-LAD before PSM but just has a lower value of the PI than LIMA-LAD after PSM. One week after CABG, coronary artery CT examination did not show statistical difference in patency rate between the two groups.

Keywords:

Coronary artery bypass grafting, Transit-time flowmeter, Internal mammary artery, great saphenous vein

Introduction:

Robert Goetz first performed and published the coronary artery bypass graft surgery in humans in 1961, now CABG has become an important revascularization methods of coronary heart disease[2]. Since the mid-1980s, owing to the high patency, the use of the left internal mammary artery (LIMA) for left anterior descending artery (LAD) grafting has been a cornerstone of CABG surgery[3]. However, owing to stenosis or occlusion of LIMA or harvested damage, surgeons have to choose other conduit materials to revascularize the LAD. The surgeons and fluid mechanics experts hold that the great saphenous vein has higher mean graft flow with less interference from external factors and is easier to anastomosis, due to its own vascular properties. A previous study demonstrated that studies on TTFM should consider conduit materials and different coronary territories, while few studies on the comparison of different conduit materials used for LAD in TTFM parameters have been reported[5]. The purpose of this study was to explore whether the great saphenous vein has more advantages in terms of TTFM parameters than the left internal mammary artery for the revascularization of left anterior descending arteries.

Material and methods:

Study population:

Data for isolated CABG were retrospectively collected from October 1, 2017 to October 31, 2019, from the Peking University People's Hospital database. There were 629 patients who underwent CABGs; we excluded 10 who underwent redo surgeries, 55 who underwent concomitant additional procedures, 134 who underwent on-pump CABGs and 20 without intro-operative TTFM data. We also excluded 34 patients who has received the RIMA for LAD revascularization. Finally, we all included 374 patients who undergoing isolated primary OPCAB with intro-operative TTFM data. According to the strategy of the LAD revascularization, 374 patients were assigned to three groups: a LIMA group(n=332), and a great saphenous vein (SVG) group (n=42). This study was approved by our institutional Review Board /Ethics Committee. Consent for individual use of data was waived because of the nature of the study and previous approval for the use of such data at the time of operative consent.

Surgical methods

Most patients underwent OPCAB through a median full sternotomy and patients underwent MIDCAB through fourth or fifth intercostal incision. The pericardium was opened and suspended to expose the heart and the heart was displaced using a posterior pericardial stitch and gauze swabs. Patients lacking good presentation of the target arteries on the lateral and inferior aspect of the heart were placed in a gentle right decubitus Trendelenburg position to assist in visualization. Stabilization of the target coronary arteries was accomplished with a tissue stabilizer (Octopus, Medtronic Corporation, Minneapolis, MN). An intracoronary shunt (Medtronic Corporation, Minneapolis, MN) was used during grafting in most operations. In this study, the LIMAs were all harvested by the pedicle method. The SVG were harvested by open harvesting method and endoscopic vein harvesting method.

Preoperative internal mammary artery ultrasonography examination

Preoperative blood flow parameters of IMAs were measured by transthoracic doppler ultrasonography machine (APLIO500 TUS-A500, Probe: PLT-704SBT and PVT-712BT). All preoperative internal mammal artery ultrasonography was performed by the same senior ultrasonologist.

Intraoperative transit time flow measurement

The transit time flow of the grafts was measured by The VeriQ system TTFM device (MediStim Inc., Oslo, Norway), equipped with2,3 or 4-mm probes, depending on the size of the graft,under stable haemodynamic conditions without the support of a mechanical device such as cardiopulmonary bypass or an intra-aortic balloon pump. The parameter yielded by TTFM system including(i) the mean graft flow volume (MGF, ml/min), (ii) the pulse index calculated as (PI, maximum flow volume—minimum flow volume)/(mean flow volume) and (iii) the DF, calculated as (flow volume of the diastolic phase)/(flow volume of the systolic phase + flow volume of the diastolic phase). Satisfactory blood flow parameters criteria : 1,ACI¿50%;2,The shape of blood flow waveform is stable and repeatable;3,PI¡5,MGF¿15ml/min. If sufficient graft flow was not obtained, graft revision was considered and performed until diastolic graft flow was confirmed.

Postoperative management

Postoperatively, aspirin, nitroglycerine and β- blocker were prescribed on postoperative day 1. The patients were routinely examined by cardiac CT scanning prior to discharge from the hospital unless they had grade 3 or more chronic kidney disease.

Statistical Analysis

The database was established by EpiDate3.1 software, the data were input twice in parallel. The final analysis database is formed after logical error checking and sorting of the input data and analysis and processing of outliers. Continuous variables were expressed as means ±SDs; if the data conformed to a normal distribution, the two groups were compared using an independent samples t test, and multiple groups were compared using variance analysis. The least significant difference (LSD) was used for pairwise comparisons among those with intragroup differences. For nonnormally distributed data, Wilcoxon rank-sum tests were used for comparisons between two groups, and Kruskal-Wallis H tests were used for comparison between multiple

groups. Categorical variables were described as percentages (rates); comparisons between two groups were performed using chi-square tests, and comparisons between multiple groups were performed using crosstabulation analysis. After we created the propensity score, patients were matched on the propensity score in a 1:2 ratio. We used calipers of width 0.2 of the standard deviation of the logit of the propensity score, as recommended in literature. Balance diagnostics were done by comparing the absolute standardized differences of the propensity scores, with values greater than 0.1 indicative of imbalance. P<0.05 was considered statistically significant. All analyses were performed in SPSS version 23.

Results

Among a total of 374 patients included in our study, 269(71.9%) were male,25(6.7%) who underwent MIDCAB. As shown in Table 1, patients in the LIMA group were younger than the SVG group before propensity Score-Matched. There was no difference in the other data.

The comparison of blood flow parameters examined by TTFM between LIMA-LAD and SVG-LAD beforepropensity Score-Matched

Compared with the LIMA-LAD group, the SVG-LAD group had a significantly higher mean graft flow volume (37.85±23.28 vs 29.70±20.97ml/min, P=0.021),but a lower value of pulse index (2.12±0.68 vs 2.65±1.01,P¡0.001).There was no significant difference between the two groups in terms of DF(P¿0.05)(Table 2).

The comparison of blood flow parameters examined by TTFM between LIMA-LAD and SVG-LAD after propensity Score-Matched

After 1:2 propensity Score-Matched, there were 114 patients were included (SVG-LAD 38, LIMA-LAD 76), there was no difference in the baseline data between the two groups.

After propensity Score-Matched, compared with the LIMA-LAD group, the SVG-LAD group also had a lower value of pulse index (2.07+-0.63 vs 2.74+-1.02,P¡0.001),and also a higher mean graft flow volume (37.27+-24.31 vs 29.92+-21.92ml/min),but there was no statistically difference(P=0.109). There was no significant difference between the two groups in DF (P¿0.05)(Table 3).

The reason for 42 patients who received SVG for LAD revascularization

There were total 42 patients who received SVG for LAD revascularization, the reasons the LIMA cannot be used are shown in Table 4. There were 5 cases that LIMA and SVG were both used for LAD; among 5 cases, there was no difference between the SVG-LAD and LIMA-LAD in term of MGF(-vs -P=0.842),PI((-vs -P=0.114) and DF((-vs -P=0.315)(Table 5). There were 6 cases that LIMA was used for non-LAD arteries(DIAG); among 6 cases, there was no difference between TTFM SVG-LAD and LIMA-DIAG in terms of PI(-vs -P=0.729),MGF(P=0.154)and DF(P=0.332)(Table 5).

Results of the CT angiography examined before discharge in the two groups.

A total of 374 patients (313 patients in the LIMA-LAD group and 43 patients in the SVG-LAD group) were examined for coronary CT angiography before discharge. Table 5 lists the coronary CT angiographic results. The patency rate of the LIMA-LAD group was 98.72% (309/313), and that of the SVG-LAD group was 100%. There was no difference between the two groups in the patency rate.

Discussion

The strategy of in situ LIMA grafting to the LAD (LIMA-LAD) is considered the "gold standard" of coronary revascularization[6].However, in some circumstances, such as the stenosis or occlusion of the LIMA and harvested damage, surgeons must choose other conduit materials to revascularize the LAD. SVG are still widely used because of their several advantages, including ease of access, ease of operation, sufficiency of length for transplantation, and short harvest time[7,8]. There is still no consensus on whether SVG grafted to the LAD could improve the flow compared with LIMA graft. Some studies have suggested that SVG grafted to the LAD has a higher blood flow (up to 35%) than IMA grafts, but other studies have

suggested that there is no significant difference between SVGs and IMAs in terms blood flow[9,10]. This study similarly showed that usage of SVG to bypass to the LAD has the advantage of higher MGF and a lower value of the PI compared with LIMA during operation. The possible explanation may be that SVGs have larger diameters and are often not be affected by vasoactive drugs and neurohumoral fluids compared to arterial conduits. However, the explanation that SVG anastomosed directly to the ascending aorta with higher pressure and a higher low-gradient can cause a larger mean blood flow volume still lacks of assertive evidence. Previous studies have shown that the flow of the LIMA graft in Chinese people is lower than that in western people which may be related to the fact that the diameter of IMA graft in Chinese people is smaller[11]. Our previous study also found that the intraoperative blood flow of an in situ IMA graft was close to the blood flow in other related research results, but the flow of the LIMA would increase significantly one week postoperatively, which was considered to be related to the intraoperative use of vasoactive drugs and self-regulation[12].

Previous studies have demonstrated that studies on TTFM should consider arterial versus venous grafts and different coronary territories[5]. However, owing to the high patency, the use of the LIMA for LAD grafting has been a cornerstone of CABG surgery; thus, few studies have compared the TTFM parameters of different conduits used for LAD. Therefore, we aimed to compare the TTFM parameters of different conduits used for LAD revascularization.

The PI, calculated as (maximum flow volume-minimum flow volume)/(mean flow volume), is one of the TTFM measurements parameters that used for conduit evaluation during operation[13].The results of Di Giammarco et al study showed that the PI¿5 may be an independent risk factors of graft dysfunction. Higher PI values indicate that there may be greater negative flow or lower average flow[14].The results of this study demonstrated that the PIs of the LIMA-LAD group are higher than those of the SVG-LAD group(P¡0.001) both before and after PSM. We also found that in this study, the proportion of negative flow less than 10ml/min was larger in the LIMA-LAD group ($P < 0.001$), suggesting that there was more negative blood flow, i.e., competitive flow, in the early systolic in the arterial conduit group. In contrast, the venous conduits have less smooth muscle, low elasticity and small cyclical deformation of pipe diameter with pressure. Therefore, it is impossible to accommodate the reverse flow by adjusting the diameter of the conduits, and the probability of the occurrence of competitive flow may be relatively low[3]. Whether the state of perfusion of arterial conduits is delayed compared with the vein conduits,which caused the different pressure perfusion, need further studies to prove it.

In this study, 5 patients whose LAD was revascularized by both SVG and LIMA due to the multiple stenosis of LAD. The revascularization of LAD is of vital importance in the treatment of CAD, and the treatment of diffuse disease of LAD are still a major challenge for cardiologists and cardiac surgeons. The 5 cases that LAD was revascularized by two grafts including SVG and LIMA all had multiple diffuse lesions and the lesion length was over 2cm. Previous studies showed that the failure rate of the diffuse disease of LAD treated by PCI was about 40-50%。Traditional endarterectomy is complicated, time-consuming and involves many uncertain factors. Incomplete dissection caused by endarterectomy, especially incomplete distal dissection of diseased vessels, will seriously affect the blood flow of bridge vessels after bypass surgery and increase the incidence of postoperative complications [15]. There was no difference between SVG-LAD and LIMA-LAD in terms of TTFM parameters in the 5 cases. Two of the five cases, the myocardial injury markers exceeded the perioperative myocardial infarction criteria within 72 hours, which may be related to poor LAD conditions. However, the results of post-operative CTA showed that all of the grafts of the 5 cases were patent.

Previous studies have shown that competitive blood flow can still be found in both the grafts of LAD and DIAG even if both the LAD and DIAG have severe stenosis. There are 6 cases that received both SVG-LAD and LIMA-DIAG revascularization. In the 6 cases, no negative waveforms (competitive blood flow) were found in SVG-LAD grafts at the early stage of contraction and the PI value of SVG-LAD were all below 3.1. The reason that the LAD was revascularized with SVG was that the poor conditions of LAD(diffuse disease) and the DIAG was relatively large with more value of revascularization. However, there was no difference between the SVG-LAD and LIMA-DIAG in terms of TTFM parameters in the 6 cases.

Owing to some patients do not have symptoms or clinical signs of myocardial ischemia prior to discharge, few studies about the acute asymptomatic graft failure have been reported and graft failure rates remain unclear[16]. However, early asymptomatic graft failure may have negative impact on the patients' short- and long-term outcomes and develop symptoms when exercise increase, because the relevant myocardial area are still unsupplied[17-19]. Cardiac CTA, as a low-invasive investigation method for the evaluation of the early grafts has been proved to be another choice besides coronary artery angiography in several studies[19, 20].CTA examination, as a part of the graft quality evaluation study in our center, was routinely used in patients who underwent CABG prior discharge. In our study, the early patency before discharge of SVG-LAD are comparable with that of the LIMA-LAD; however considering the long-term patency, the LIMA were recommended over SVG.

Limitations

Several limitations of our study should be recognized. Firstly, this study was its descriptive nature, using a relatively small cohort of patients at a single institution. Secondly, blood flow parameters measured by TTFM and early prior to discharge graft patency do not reflect the all of the advantages of the effect of the grafting strategy; in addition, major cardiovascular and cerebrovascular adverse events, revascularization events and the long-term graft patency can reflect the advantage of grafting strategy to the LAD. These other indicators were not included in this study.

Conclusions

SVG-LAD has a higher intraoperative MGF and a lower value of the PI than LIMA-LAD before PSM but just has a lower value of the PI than LIMA-LAD after PSM. One week after CABG, coronary artery CT examination did not show statistical difference in patency rate between the two groups.

List of abbreviations

LIMA: left internal mammary artery

LAD: left anterior descending artery

CABG: coronary artery bypass graft surgery

TTFM: transit-time flow measurement

PI: pulse index

MGF: mean graft flow

DF: diastolic flow fraction

SVG: great saphenous vein

CTA: computed tomography angiography

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

We received explicit consent from the patient.

Availability of data and material

Data will be made available on request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

Yu Chen is the corresponding author. Guodong Zhang and Zhou Zhao conceived of the study and participated in its design and coordination. Yu Chen, Gang Liu and Shenglong Chen helped to draft the manuscript. All authors read and approved the final manuscript.

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